REPORT NO. UMTA-MA-11-0026-81-2

INFORMATION ABOUT VISUAL IMPAIRMENT FOR ARCHITECTS AND TRANSIT PLANNERS

VOLUME II OF II

CONCERNING

IMPROVING COMMUNICATIONS WITH THE VISUALLY IMPAIRED IN RAIL RAPID TRANSIT SYSTEMS

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16. Abstract

This document presents a collection of reports prepared as part of a project which studied communication with the visually impaired in rail rapid transit systems. The documents should be of help to architects and transit planners who are attempting to design environments which are free of barriers to the visually handicapped.

The following reports are included: 1) An Annotated Bibliography of Selected References on the Visually Handicapped; 2) Considerations in the Design of Information Systems for Communicating with the Visually Handicapped; 3) An Annotated Bibliography on the Use of Transit by the Visually Impaired; 4) A Glossary of Definitions Related to Visual Impairment; and 5) The Incidence and Demography of the Visually Impaired in the United States.

This document represents Volume II of a 2-volume report on a project entitled "Improving Communications with the Visually Impaired in Rail Rapid Transit Systems." The other volume is entitled (Volume I) "Solutions for Problems of Visually Impaired Users of Rail Rapid Transit."

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METRIC CONVERSION FACTORS

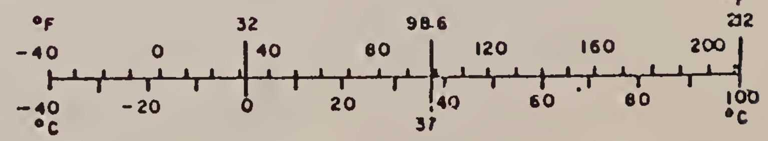
Approximate Conversions to Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
		MASS (weight)		
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
		VOLUME		
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

*1 in = 2.54 (exactly). For other exact conversions and more detailed tables, see NBS Misc. Publ. 286, Units of Weights and Measures, Price $2.25, SD Catalog No. C13.10:286.

Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
		AREA		
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
		MASS (weight)		
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
		VOLUME		
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
		TEMPERATURE (exact)		
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



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INTRODUCTION

Architects, transit planners, engineers and others who design transit facilities and transportation vehicles need to be aware of the range of abilities and disabilities present in the riding public. Consideration of the human performance capabilities and the unique needs of riders who do not conform to "average" specifications can lead to the planning of vehicles and facilities which are accessible to a much greater number of potential users.

This document presents information pertinent to a general understanding of visual impairment and the visually impaired, as well as specific information on the characteristics of accommodations which are typically made for this population.

The "Annotated Bibliography of Selected References on the Visually Handicapped" presents a brief collection of books, monographs, and journal articles about visual impairment which have been annotated for use by transit personnel. Four major themes are covered: 1) Nature of Visual Impairment and Demography of the Population; 2) Psychosocial Aspects of Visual Impairment; 3) Education and Rehabilitation of the Visually Impaired; and 4) Public and Private Community Resources.

The "Annotated Bibliography on the Use of Transit by the Visually Impaired" presents abstracts of eight books and articles which dealt with this topic prior to 1981.

The paper entitled "Incidence and Demography of Visual Impairment in the United States" presents a critical review of the studies conducted within the U.S. since 1963 on the size and distribution of this population. This paper also attends to estimates of certain special characteristics, such as the number of braille readers, the number of dog guide users, and the number of visually/

multihandicapped people.

The paper entitled "Considerations in the Design of Information Systems for Communicating with the Visually Impaired" summarizes the accepted practices ("standards") for the use of Braille, raised print, large type, color, graphic displays, textures, audio cueing, and electronic cueing when these modes are used to communicate with the visually impaired.

Finally, a 107 item "Glossary of Definitions Related to Visual Impairment" is included. This glossary is written in language which is understandable by readers who are unfamiliar with the jargon of professionals in the fields of vision and blindness.

The works included herein were generated as part of a project entitled "Improving Communications with the Visually Impaired in Rail Rapid Transit Systems". Volume I of the report on this project("Solutions for Problems of Visually Impaired Users of Rail Rapid Transit" Report No. UMTA-MA-0036-81-1) presents the results of a one year intensive study of the accessibility of 3 major rapid rail systems in the U.S., and a collection of suggested techniques for solving the problems which were identified.

ANNOTATED BIBLIOGRAPHY OF SELECTED REFERENCES ON THE VISUALLY IMPAIRED

Introduction

The following annotations represent general and important works in the field of blindness and visual impairment. Individuals involved in the planning of transit systems who want to examine the particular needs of visually handicapped travellers should find a variety of information sources in these selections. Each item contains a statement of content and a remark about its relevance. While this compilation is not intended to be exhaustive, it does represent what experts in the field of visual impairment consider to be of significant value.

The references are divided into four categories: 1) Nature of Visual Impairment and Demography of the Population; 2) Psychosocial Aspects of Visual Impairment; 3) Education and Rehabilitation of the Visually Impaired; and 4) Public and Private Community Resources. It should be noted that works cited in one section may also discuss topics from other sections, but all works are classified by their main contribution.

Demography of the Visually Impaired Population

Goldstein, H. The demography of blindness throughout the world. New York: American Foundation for the Blind, 1980.

This is the most complete, up to date, sophisticated work on the distribution of blind individuals throughout the world. The statistical tables tend to be world-based rather than U.S. based, but the methods of breakdown are quite exhaustive of the important categories. Furthermore, the discussions of problems in estimating incidence and in obtaining accurate data are important. This can be considered a very reliable source of demographic data for transit planners.

Hatfield, E.M. Blindness in infants and young children. The Sight-Saving Review, 1972, 42 (2), 69-89.

This is a report of the results of a study of blind infants and children under seven years of age by the National Society for the Prevention of Blindness, in 1967. The study presents demographic data as well as distributions by sex, age, age at onset, degree of vision, and causes of blindness. At least some of these data could be of use in projecting the numbers of potential visually handicapped travellers in various places.

The visually impaired population as a market for sensory aids and services. New York: American Foundation for the Blind, 1973.

This brief (44 pages) book describes, in laymen's terms, many of the problems associated with blindness and many of the requirements of blind people for sensory aids. Some simple demographic data are also included. The book could be a useful introduction to the advantages and limitations of sensory aids, as well as a simple introduction to some important demographic data.

Psychosocial Aspects of Visual Impairment

Carroll, T.J. Blindness: What it is, what it does, and how to live with it. Boston: Little, Brown & Co., 1961.

This book outlines a program of rehabilitation for newly blinded adults. Based on the assumption that sight loss results in a uniform set of reactions and produces a common set of needs, the author recommends a total residential approach to rehabilitation. Twenty losses associated with blindness are identified in the context of human functioning. Likewise, twenty restorations are revealed which bring the individual back to level total adjustment. Aside from the basic methodological information, this book transmits a deep analysis of the psychological impact of sight loss.

Cutsforth, T.D. The blind in school and society. New York: American Foundation for the Blind, 1951.

Considered to be the most often quoted book in the blindness literature, the writer assumes a very negative position with regard to residential approaches to the education of blind children. Though considerably dated, the dynamics of misguided professionals are analyzed with great depth and sensitivity in this work. Rich with case study illustrations, the author relates early familial experiences and educational practices to adult social maladjustment.

French, R.S. From Homer to Helen Keller: A social and educational study of the blind. New York: American Foundation for the Blind, 1932.

This work represents a historical survey of work for the blind. Major achievements are described with great attention to the individuals involved. The results of individual efforts by the blind in overcoming the functional and social obstacles of sight loss is emphasized. One can gain a perspective of where blind people have been delegated in earlier societies, and why in many cases certain opportunities remain withheld.

Koestler, F.A. The unseen minority: a social history of blindness in the United States. New York: American Foundation for the Blind, 1976.

An in-depth text, the author discusses the history of social, rehabilitative, and educational services to blind people in the United States. Legal rights, welfare legislation, demographic changes, societal expectations, career/vocational patterns, the impact of technology and educational as well as rehabilitational advances are all described with great detail and specificity. One can gain a keen sense of the rights of the handicapped by reviewing in this work the milestones of social struggle.

Monbeck, M. The meaning of blindness: attitudes toward blindness and blind people. Bloomington, Ind.: Indiana University Press, 1973.

While blindness has a common sense meaning, simply denoting the absence of vision, its use evokes a great deal more meaning. The public's reaction to blindness and blind people will depend on the expectations of individuals. Determined by a variety of factors, these expectations comprise the host of

attitudes toward the blind. The author explores the origins, persistence and pervasiveness of such beliefs about blindness. For those interested in improving human interactions between blind and sighted individuals, this book provides some valuable insights.

Scott, R. The making of blind men. New York: Russell Sage Foundation, 1969.

From the perspective of sociology, the author critically examines the notion that blindness results in a uniform set of characteristics. Rather, those stereotypes that blind people are assumed to hold in common are acquired through the ordinary processes of socialization. Of particular value here is Scott's attack on the logic of inferring that blindness must by necessity results in helplessness, dependency, melancholia and serious-mindedness.

Warren, D.H. Blindness and early childhood development. New York: American Foundation for the Blind, 1977.

For those interested in the underlying status characteristics of the blind, this book provides an exhaustive review of basic research findings. Concluding that inquiry into the nature of congenital blindness has produced equivocal findings, the author attacks the validity of some of the researcher predispositions and methodological procedures. A number of practical suggestions are offered for those intending to do research with blind subjects.

Education and Rehabilitation of the Visually Impaired

Allen, W., Griffith, A., and Shaw, C. Orientation and mobility: behavioral objectives for teaching older adventitiously blind adults. New York: New York Infirmary Center for Independent Living, 1977.

This volume is a basic and practical source of information on how to guide visually impaired individuals safely and efficiently. Further, it addresses the teaching of indoor protective techniques, and outdoor travel procedures. Though intended for professionals, it is useful to all because of the precise behavioral terminology used in its format.

Apple, L.E., and May, M. Distance vision and perceptual training. New York: American Foundation for the Blind, 1970.

Based on a selective review of the literature in perceptual psychology and clinical observations, the work outlines a program for improving the use of distance visual behavior in adults who have suffered serious sight loss. Several mutually exclusive areas of visual behavior are covered. For those interested in understanding some of the functional components of sight loss, this work provides a most precise analysis.

Bentzen, B.L. Orientation aids. In R.L. Welsh and B.B. Blasch (eds.), Foundations of Orientation and Mobility. New York: American Foundation for the Blind, 1980.

This is the most complete review of research and practice regarding design of models, graphic aids (maps), and verbal aids (auditory maps) to spatial orientation of visually impaired persons. The focus of the chapter

is theory and practice. Transit planners will find rationale and suggestions for the design of tactile and large print maps.

Blasch, B. and Apple, L. *Workshop on low vision mobility*. Kalamazoo, Mich.: Western Michigan University, 1975.

This volume represents a collection of papers presented at a conference of orientation and mobility specialists. All papers discuss the travel implications of severe visual impairment. Perceptual processes, vision training approaches and functional assessment techniques are described for individuals interested in improving the use of distance vision for travelling.

Braf, P. The physical environment: the visually impaired. ICTA Information Center, Bromma, Sweden, 1974.

Describes the planning and adaptation of buildings and other physical environments for visually impaired persons. Particular attention is paid to plans which facilitate orientation. A small section on public transit stations is included.

Dunkin, J., Gish, C., Mulholland, M.E. and Townsend, A. *Environmental modifications for the visually impaired*. New York: American Foundation for the Blind, 1977.

This book summarizes ANSI standards which have implications for visually impaired travellers. It also gives names and addresses of persons involved in the committee on architectural and environmental concerns of the visually impaired standing committee of the American Association of Workers for the Blind.

Enzinna, A.J. Additional handicaps. In R.L. Welsh and B.B. Blasch (eds.), *Foundations of Orientation and Mobility*. New York: American Foundation for the Blind, 1980.

A review of the consequences for independent mobility of handicaps commonly occurring together with blindness. Included are orthopedic handicaps, diabetes, hearing loss, cerebral palsy and mental retardation. Transit planners should be aware of the additional orientation and mobility problems encountered by persons who have these concommitant handicaps; such persons are able to use and need to use rail rapid transit.

Farmer, L.W. Mobility devices. In R.L. Welsh and B.B. Blasch (eds.), *Foundations of Orientation and Mobility*. New York: American Foundation for the Blind, 1980.

This chapter describes and reviews the use, advantages and disadvantages of various canes and electronic travel aids, including the Pathsounder, Laser Cane, Sonicguide, Mowat Sensor, Nottingham Obstacle Detector and electrocortical prostheses. Although not yet in common use, electronic travel aids used in addition to or instead of the long cane have the potential for detecting and aiding identification of obstacles at greater distances than the long cane alone. Their users could potentially move in greater safety and confidence in complex areas such as rapid transit stations.

Foulke, E. The perceptual basis for mobility. American Foundation for the Blind Bulletin, 1970, 23, 1-8.

This article discusses the necessity of learning an environmental schema for safe, independent orientation and mobility. Redundant architecture such as consistent placement of fare collection devices directly in front of stairs will facilitate spatial orientation of blind rapid transit users.

Hanninen, K.A. Teaching the visually handicapped. Columbus, Ohio: Charles Merrill, 1979.

This work covers the basic principles and strategies employed in the education of the visually handicapped. Historical developments, alternative programs, special methods and adapted materials are also covered. The chapter organization permits easy location of specific information for presenting appropriate material to the visually impaired.

Hill, E. and Ponder, T. Orientation and mobility techniques: a guide for the practitioner. New York: American Foundation for the Blind, 1976.

This book presents procedures and rationale for procedures used by travellers with long canes. Included are sections on public transportation (including subways and elevated trains), escalators, elevators, and revolving doors.

James, G.A., Armstrong, J.D. Handbook on mobility maps. Blind Mobility Research Unit, Department of Psychology, University of Nottingham: Nottingham, England, 1976.

This is a manual for the design and production of mobility maps for the blind,including verbal maps and tactile maps. It emphasizes low and intermediate technology uses and is a guide for the novice who wishes to produce helpful maps of transit stations and routes.

Kidwell, A.M. and Greer, P.S. Sights, perceptions and the nonvisual experience: designing and manufacturing mobility maps. New York: American Foundation for the Blind, 1973.

This work describes design and production of a tactile maps of Massachusetts Institute of Technology in polyvinylchloride. It gives an excellent description of spatial perceptual problems experienced by the blind traveller in complex indoor and outdoor environments.

Lowenfeld, B. (ed.) The visually handicapped child in the school. New York: John Day, 1973.

This volume represents a compilation of chapters, each of which is authored by an authority noted for their particular expertise. Chapters deal with psychological considerations, educational principles, administrative plans, low vision utilization, special subject adjustments and orientation, mobility and physical skills. This volume serves as an excellent reference source, as each chapter stands alone with its particular content.

Wardell, K.T. Environmental modifications. In R.L. Welsh and B.B. Blasch (eds.), Foundations of Orientation and Mobility. New York: American Foundation for the Blind, 1980.

This chapter defines and describes travel hazards for totally blind and low vision persons. It gives suggestions for their amelioration. This well-illustrated chapter will sensitize transit planners to common environmental structures which are hazardous to the visually impaired. Implementation of the suggestions of this chapter in stations should result in safer travel for blind persons.

Von Gruenigen, S. A preliminary investigation into the development of a tactual mapping program at Ohio State University. The Ohio State University, Department of Geodetic Science, 1979.

This presents an excellent review of current production techniques for tactile maps, and includes cost comparisons.

Public and Private Community Resources

The directory of agencies serving the visually handicapped in the United States. New York: American Foundation for the Blind, 1980.

This is an exhaustive compilation of federal, state, and private agencies which provide services to visually impaired people. It is organized for convenient use and should be considered the authoritative reference work on this topic. It is updated annually.

Hard, R.E. and Cull, J.G. Social and rehabilitation services for the blind. Springfield, Illinois: Thomas, 1972.

This book includes contributions from many authorities in the field of blindness. The history of service, the development of legislation, the composition of the population served, and the rehabilitation process are all covered with noteworthy detail. This volume is so well organized that it can serve as a useful reference for any information on the subject of rehabilitation for the blind.

International guide to aids and appliances for blind and visually impaired persons. New York: American Foundation for the Blind, 1977.

A wide array of mechanical and electronic aids and appliances designed for use by blind individuals are currently available. This work represents an effort to combine in a single volume information concerning devices from all over the world in such areas as orientation and mobility, written communication, tactual measurement and recreation. Individuals concerned with the design of compensatory aids should find this work helpful.

AN ANNOTATED BIBLIOGRAPHY ON THE USE OF TRANSIT BY THE VISUALLY IMPAIRED

Introduction

After a complete literature search, works specifically addressing the use of transit by the blind have been annotated in the following bibliography. Articles covering topics such as maps, environmental barriers, and travel techniques taught to and used by visually impaired travellers have been included.

Allen, W., Griffith, A., and Shaw, C. Orientation and mobility: behavioral objectives for teaching adventitiously blind individiuals. New York: New York Infirmary/Center for Independent Living, 1977.

This volume is a basic and practical source of information on how to guide visually impaired individuals safely and efficiently. Though intended for use by professionals, it is useful to all because of the precise behavioral terminology used in its format. It addresses the teaching of indoor protective techniques, and outdoor travel procedures.

It also includes clear descriptions of the techniques and general rules taught to visually impaired travellers using the subway and other public transportation systems.

Bentzen, B.L. Orientation maps for visually impaired persons. Journal of Visual Impairment and Blindness, May 1977, 193-196.

Two types of tactile maps -a relatively simple map of the Boston rapid transit system and a detailed map of the Boston-Cambridge area — have been compared in this study. Eighteen visually impaired travellers received copies of both maps and were offered instructions in their use. After planning and travelling at least one unfamiliar route using each map, the visually impaired participants filled out a questionnaire and participated in group discussion. The article concludes that both simple and complex maps can be of assistance in independent travel, given that adequate map usage instructions (person-to-person; or tape or written) are available.

Braf, P. The physical environment and the visually impaired. Bromma, Sweden: ICTA Information Centre, 1974.

This publication discusses the planning and adaptation of the physical environment to increase accessibility for the visually impaired. Particular attention is paid to details which simplify the orientation process, including factors such as geometric layout, colors, lighting and both positive and negative effects of sound.

Orientation is easier if large areas are broken down into smaller, rectangular areas and if paths and circulation patterns keep to a right angle system. Benches and other furnishings should be at the side of pedestrian routes. Doors and gates must open with the main direction of traffic, and be placed so they do not become obstacles. Handrails can provide directional information as well as safety. The level of the platform should be at the same height as the floor of vehicle at the entrance point, and should slope away from the track. The main circulation area

should be along the part of the platform furthest from the track.

Contrasting colors can be used to simplify orientation, and indicate the location of stairs, the main circulation paths, and the edge of the platform. Yellow, orange, light green, are the most readily experienced colors. Proper illumination is essential, and can be used to aid orientation. Diffusely reflective materials and well shielded light sources will prevent dazzling or confusing reflections.

Sound information should complement optical signs. Sound beacons can indicate the position of doors. In the station, the vehicular noises need to be dampened so the other sounds can be distinguished.

Duncan, J., Gish, C., Mulholland, M., and Townsend, A. Environmental modifications for the visually impaired. Journal of Visual Impairment and Blindness, New York: American Foundation for the Blind, December 1977, 442-455.

This document describes standards and comments and suggestions for interior and exterior environmental modifications to aid the visually impaired. The descriptions have been chiefly based on American National Standards Institute and General Service Administration standards. Of interest to transit personnel will be the discussions of doors, floors, stairs and ramps, elevators, emergency exits, restrooms, building hardware, signs and symbols, alarm systems, public telephones, entrances, walks, and the pertinent use of color, acoustics, and lighting.

Hill, E. and Ponder, P. Orientation and mobility techniques: a guide for the practitioner. New York: American Foundation for the Blind, 1976.

This book presents procedures and rationale for procedures used by travellers with long canes. Included are sections on public transportation (including subways and elevated trains), escalators, elevators, and revolving doors.

James, G. and Swain, R. Learning bus routes using tactual map. The New Outlook for the Blind, 1975, 69 (5), 212-217.

An article describing a tactual map with two overlays indicating bus routes of Nottingham City Centre. Four blind individuals (one had light perception) were systematically taught to use the map. They were then asked to track their route on the map while travelling on the bus, and to give a verbal description of any environmental cues that gave them up-to-the-minute information about their location. None of the subjects had travelled on the buses previously. Three subjects followed the map with no errors, one became disoriented due to left/right confusion at a turn near the route's end. Article concludes that tactural maps can greatly enhance a blind person's knowledge of the city; and enable him to use a transportation system without prior direct experiences.

Snyder, G. (Chairman). Accessibility of public transportation to the consumer who is visually impaired. Recommendations of the Sub-Committee on the Visually Impaired of Policies and Practices Committee, Massachusetts Bay Transportation Authority, 1980.

The recommendations contained in this document resulted from group discussions by visually impaired consumers, representatives of advocacy groups, and professionals in the field of education and/or rehabilitation of

the visually impaired. Their suggestions range from the design and placement of above ground entrances and staircases to the use of tactile strips and color contrasts.

Wardell, K. (Chairman). Guidelines: Architectural and environmental concerns of the visually impaired person. Sub-committee on Environmental Concerns of American Association of Workers for the Blind Interest Group Nine, 1977.

This brochure presents an overview of architectural hazards affecting the visually impaired traveller, and makes suggestions for their remediation.

THE INCIDENCE AND DEMOGRAPHY OF VISUAL IMPAIRMENT IN THE UNITED STATES

Available data on the incidence and demography of blindness are incomplete and of suspect reliability. None of the population studies have been sufficient in scope to precisely identify the characteristics of this population in any reliable manner.

It must also be pointed out that this handicapped population represents a very small percentage of the total population of the United States (less than .01%). Therefore, samples selected using normal sampling procedures are subject to greater than normal error.

The numerous restrictions observed when deriving a sample population representative of the entire U.S. population (due to cost, privacy, etc.) make appropriately generalizable population studies difficult to design. This process has been beset with additional difficulties within the blindness field due to conflicting definitions of blindness and differing methods of determining visual function.

Nevertheless, various data collection techniques and estimating procedures have been attempted and a few studies have been conducted within the past two decades. Estimates generated by these studies are discussed below.

The National Health Interview Surveys (1963-1964) determined their estimates from responses during a house-to-house canvas of representative urban families. Severe visual impairment was recorded for negative responses to the question "Can you read ordinary newsprint with glasses?" It should be noted, however, that this type of data collection is highly unreliable because of such factors as self-reporting, the variation of reading distances, possible visual improvements with other corrective lenses and other similar factors.

The Model Reporting Area (MRA) for Blindness Statistics was formed to facilitate more uniform collection of blindness statistics by the Biometrics Branch of the National Institute of Neurological Disease and Blindness (NINDB). For their purposes, blindness has been defined as visual acuity of 20/200 or less in the better eye with best correction, or visual acuity of greater than 20/200 if the widest diameter of the visual field subtends an angle no greater than 20 degrees (which is the typical requirement for Supplemental Security Income eligibility and for special services for the visually handicapped). Additional standards were followed by the sixteen MRA states during the 1970 data collection. Unfortunately, this program was phased out after 1971 in favor of other epidemiologic and statistical activities.

Although the population of the 16 states participating as Model Reporting Areas in the 1970 study comprised approximately 1/3 of the population of the entire U.S. population, the population does not represent all ethnic or geographical sections of the U.S., and their statistical findings cannot justifiably be generalized to the entire U.S. population. The MRA collection, though more uniform in definition and classification procedures than other register systems, still depended on thorough reporting of blindness cases by ophthalmologists and other blindness system professionals. Selective under-reporting by these people due to personal biases, forgetfulness, and other factors probably occurred. The degree of under-reporting is unknown, but the MRA is thought to understate the population size (Goldstein, 1980). Under-reporting is considered to be especially prevalent in the older age group (65+). This group may also have missed the blindness register because they received aid from agencies for the elderly and may not have been listed on the blindness register as well.

There are particular tendencies reported in the 1970 MRA study worth

noting:

1) In this publication, at least 45% of all persons on the register 65 years and older, and 43% of the new cases were within this age group.

2) The addition rates to the register have been approximately 10% of the rate on the register. (Additions to the register do not necessarily indicate the number of new cases or even the newly diagnosed cases.)

3) The rates for blindness in males are slightly higher than those for females until the older age range (65+). This shift is probably due to the larger proportion of females who reach the older age bracket.

4) Generally, there is a higher incidence of blindness within the non-white population than the white population.

5) The causes of blindness shift within age groups. The most pertinent causes for the purpose of this study include retinal disease (diabetic and other), uveitis, glaucoma, and - in the older population - senile cataracts.

Although the trends are noteworthy, the lack of a true representative sample population would prohibit their use as indicators of prevalence and incidence in the complete U.S. population.

Hatfield (1970) estimated the size of the U.S. blind population using a weighting system. The formula involved projecting the population data collected from six of the MRA states to other states via a weighting system for other pertinent population characteristics. The limitations of this technique include the problems previously discussed for MRA systems such as underreporting, and other perils of projecting findings from a collection of six states to the other 44. Unfortunately, there is also no way to

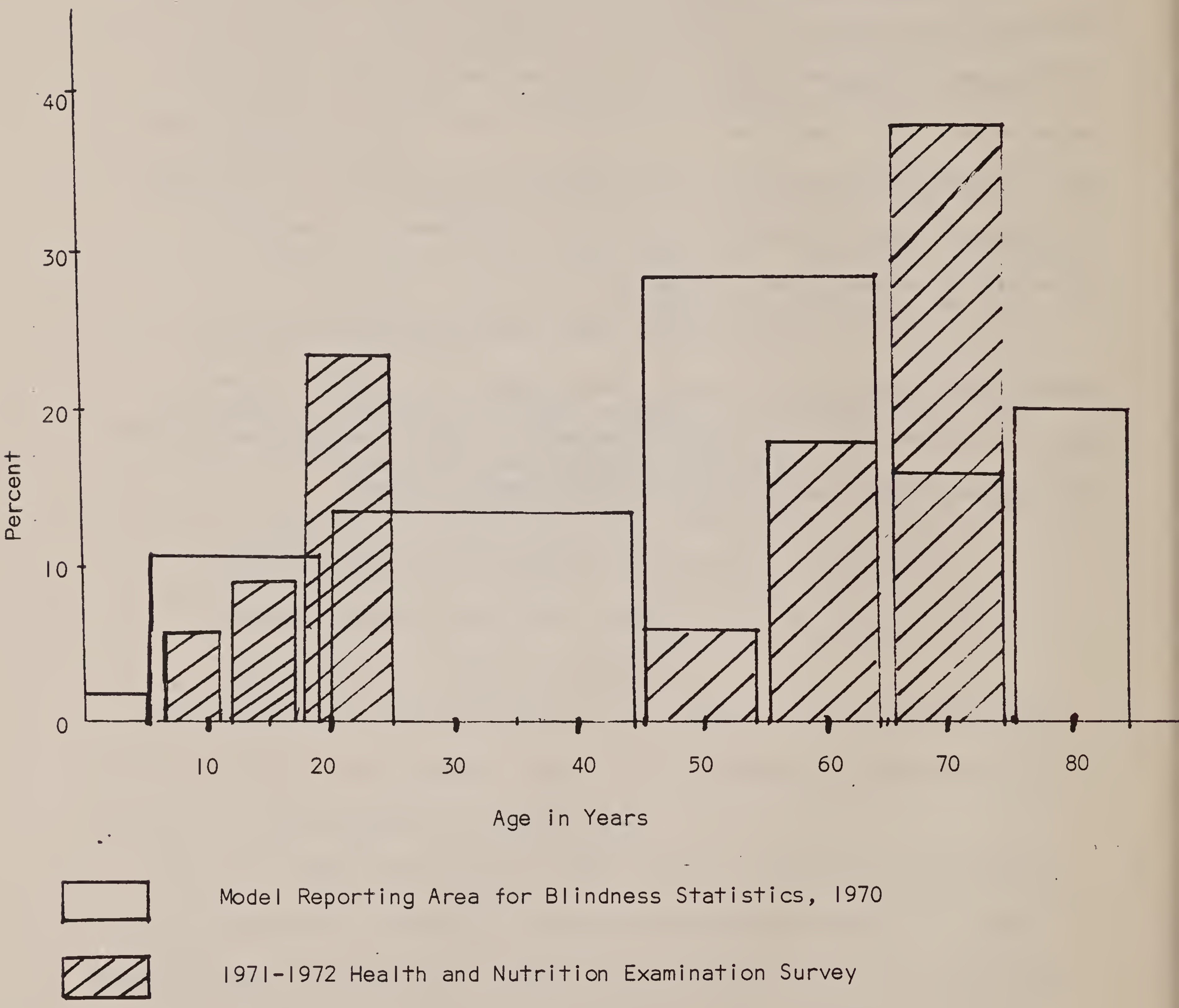
validate these estimates.

The first to report findings based on ophthalmological examinations of a statistically-based sample of the United States population was the Health and Nutrition Examination Survey, conducted in 1971-1972 by the National Center for Health Statistics for the age group 4-74 years. A sample of 14,497 persons representing the 192.7 million Americans aged 4-74 years was selected. The people were requested to report for an ophthalmological exam. Seventy-three percent of those requested participated. The reduced participation rate is thought to cause an understatement of the actual prevalence of severe visual handicaps.

As can be seen in the following Table, the percent distribution of persons with 20/200 acuity differs greatly from that indicated by MRA data. One particularly striking discrepancy is the lack of persons reported with severe visual impairment in the 25-44-year-old range.

Table I.

Comparison of percent distribution by age of persons with 20/200 or worse visual acuity as reported by the National Center for Health Statistics 1971-1972 Health and Nutrition Examination Survey and the Model Reporting Areas for Blindness Statistics, 1970.



Adapted from Goldstein, Table 2 and Table 30.

Table 2 summarizes the findings of various other blind population studies, and confirms the lack of agreement on total population size.

Table 2.

Estimates of the number and rate per thousand of the blind and severely visually impaired non-institutionalized population, United States.

STUDY	NUMBER	RATE PER THOUSAND
1. Estimate of the legally blind from 14 states in the Model Reporting Area for Blindness Statistics (1965)	290,000	1.5
2. Estimate of the legally blind by the National Society for the Prevention of Blindness (1972) (derived from Hurlin estimates)	467,800	2.1
3. Number in population aged 4-74 reaching specified acuity levels--Health and Nutrition Examination Survey (1971-1972)	630,000	-
4. Number of persons 6 years of age and over who cannot read newsprint with glasses (1963-1964) National Health Interview Survey	1,227,000	6.6
5. Number of persons 18-79 years of age testing at 20/200 or less "corrected" distance vision (1960-1962) National Health Examination Survey	889,000	8.0
6. Number of persons reporting "severe vision impairment" (1963-1964) National Health Interview Survey	1,227,000	6.6
7. Number of persons 6 years of age and over who cannot read newsprint with glasses (1971) National Health Interview Survey	1,306,000	6.5

Adapted from Table 33, p. 184, Goldstein

Other Population Characteristics

Due to the contradictory estimates of the incidence and prevalence of blindness, it is very difficult to predict other characteristics within the population with accuracy.

However, of particular relevance to this project is an estimate of the number of the blind who would use and benefit from braille signs and maps (or large print maps). Goldish (1980) postulated that fewer than 160,000 people need to use braille, but his estimate was derived using the same formula used by Hatfield (1970), which was criticized earlier in this report.

Reading of braille varies with age and onset of blindness as well as educational factors. Goldish (1980) estimated that of the number of legally blind, 11% (about 45,000 people) read braille and 8% (33,000) use it as their primary mode of communication. By age group, 52% of the legally blind population under 20 years of age learn to read braille, 20% of the 20-39 age group, 10% of the 40-64 age group and only 3% of the legally blind population over the age of 65 read braille.

It is even more difficult to determine the number of persons who rely on large print. No population studies have been done in the U.S. in this area, although various agencies have stated particular recommendations.

Another important statistic for the purpose of this study is an estimate of the number of blind persons with more than one handicap. Additional handicaps usually complicate the travel abilities of the visually impaired. The National Center for Health Statistics 1971-1972 Health and Nutrition Examination surveyed combinations of impairments. Out of the estimated 47,424,000 non-institutionalized people with some type of impairment, they reported 1,306,000 as having severe visual impairment only, and the following combinations of impairments including vision (not necessarily

severe):

Vision and hearing	2,559,000
Vision and speech	130,000
Vision and paralysis	256,000
Vision and absence of extremity	148,000
Vision and other orthopedic	1,927,000

These estimates obviously are not of the "legally blind" population alone, although some legally blind persons would be included. The techniques used in this survey have been critiqued previously.

The number of visually handicapped persons who are trained to travel is unknown. Seeing Eye Institute estimates that between 2 and 5% of the blindness population could use a dog guide, but does not have exact numbers of persons who do use them.

No estimates of the number of people who use the long cane with or without training have been published. Also, no estimates have been made of the number of persons who use electronic travel aids, although most experts consider this population to be less than 1% of the blind population.

It is obvious that more research is needed on the incidence, prevalence, and distribution of blindness. The results of those studies which have been done cannot be considered reliable because of a lack of consistent definition of visual impairment, differing methods of determining visual needs, and a lack of consistent procedures for the reporting of visual handicaps.

These same factors also preclude the possibility of making reliable judgements on the size or distribution of sub-populations such as the elderly blind or the visually travel-impaired. The estimates discussed in this section

reflect the state-of-the-art as of 1981, and until such time as the overall incidence is better known, it seems prudent to avoid making further breakdowns.

CONSIDERATIONS IN THE DESIGN OF INFORMATION SYSTEMS FOR COMMUNICATING WITH THE VISUALLY IMPAIRED

Introduction

Information systems commonly used for communicating with the visually impaired include braille, raised print, large type, color, graphic displays, textures, audio cueing, and electronic cueing. Standards (or guidelines, or suggested techniques) exist for the production and use of some of these systems. However, most of these standards have been established by experience and expediency, and reinforced by tradition.

This paper summarizes the standards for communication with visually impaired persons by means of braille, raised print, large type, color, graphic displays, textures, audio cueing, and electronic cueing. Where standards have been based on empirical evidence, this is so stated. It will be evident, however, that further research in perception by and communication with the visually impaired is critically needed.

Braille

Braille is the most commonly used system for printing and writing for totally blind readers. It consists of raised dot patterns which represent letters, numbers, punctuation marks, and composition signs.

All of the characters of braille are chosen from the 63 possible combinations of positions and numbers of dots within a braille cell. The braille cell consists of an array of six equally spaced positions, three high by two wide.

The standard dimensions for braille are as follows:

1) base diameter of dot, .060 inch

2) height of dot, .017 inch

3) distance between centers of adjacent dots within a cell, .090 inch

4) horizontal dimension of one cell plus the space between that cell and the next, .241 inch

5) vertical dimension of one cell plus the space between that cell and the next (on line below), .395 inch (Friedman, 1980).

The dot shape (based on tactual discriminability) is conical and rounded (Nolan & Kederis, 1969).

A smaller cell size (referred to as micro dot braille) is used in some contexts in England but has not been approved for use in the United States by the American Association of Instructors of the Blind - American Association of Workers for the Blind (AAIB-AAWB) Braille Authority. It is readable by a smaller proportion of touch readers than standard braille, and therefore not recommended for materials produced for a large, but unknown group of blind persons.

A larger cell size (referred to as jumbo braille) is sometimes used in small labels (e.g., those available for elevator buttons). Readers of standard braille do not normally have difficulty reading jumbo braille, but they find it slower than standard braille for reading text. Persons with reduced tactile sensitivity (due to disease such as diabetes, or to callus, or cold) are often better able to read jumbo braille than standard braille. In addition, adventitiously blinded persons who sometimes do not become proficient braille readers, may often be able to read labels in jumbo braille. The dimensions for jumbo braille are as follows:

1) base diameter of dot, .066 inch

2) height of dot, .017 inch (same as standard braille)

3) distance between centers of adjacent dots within a cell, .121 inch

4) horizontal dimension of one cell plus the space between that cell and the next, .375 inch

5) vertical dimension of one cell plus the space between that cell and the next, .500 inch (Friedman, 1980).

There are several different "grades" of braille as well as special codes for music and mathematics. The two "grades" of braille relevant to this study are "English braille grade 1", which uses full spelling and "English braille grade 2", which is a highly contracted system consisting of grade 1 and 189 contractions and abbreviated words.

Most braille literature is produced in grade 2. This is the form of braille which is preferred by efficient braille readers because it is faster and takes less space than grade 1. However, a majority of adventitiously blinded persons do not become proficient braille readers. They learn only enough braille to read short messages and labels in grade 1.

The recommendations of these investigators for braille as used in transit or public buildings, are therefore:

1) Where considerable reading is involved, (as in schedules produced for distribution), standard, grade 2, braille should be used;
2) Where small labels are involved (as in elevators), jumbo, grade 1, braille should be used.

Raised Print

A majority of braille readers can also read raised print (capital letters in block type), if letters are sufficiently high. However, the limited research regarding optimal height of raised print letters for tactile reading is not conclusive. Schiff (1966) found seventeen embossed upper case letters legible by visually impaired college students, at a height of 9/16 inch (14.6 mm) and a stroke width of 1/16 inch (1.6 mm). Tactile sensitivity decreases with age and callus, and it is reduced by diabetes, a common cause of blindness. Therefore, a height of 14.6 mm is probably somewhat

too small for many touch readers. Both ANSI* and ATBCB** recommend raised or incised type at least 5/8 inch (16 mm) high and no higher than 2 inches (50 mm). In the absence of further research, these investigators will follow the ANSI and ATBCB recommendations.

Although larger than the optimum size for large print for extensive or close reading, 16 mm raised letters which contrast from their background are a good compromise where labels are called for, as they will be readable by a majority of both touch and sight readers.

The use of incised type is not to be considered an aid to visually impaired persons. Incised figures are only minimally legible to visually impaired persons (Nolan, 1971).

Large Type for Near and Distant Reading

Large Type

SStandards for production of large type for reading have been published by the National Association for the Visually Handicapped (NAVH). They recommend 18 pt. sans serif type (having upper case letters approximately 5 mm high), and this type size is used in most large type publications. The only empirical evidence indicating that this size is optimal seems to come from Nolan (1959) who found that 18 pt. type may be legible for more low vision children than larger or smaller print. However, somewhat larger type may be better for adults who no longer have the powers of accommodation to achieve greater enlargement, if necessary, by bringing print very close to their eyes. Shaw (1969) found that increasing the boldness of type improved legibility for most partially sighted readers, but she did not propose an optimum size.

*American national standard specifications for making buildings and facilities accessible to and usable by physically handicapped people. New York: American National Standards Institute, Inc., 1980.

**Architectural and Transportation Barriers Compliance Board (1981). Proposed minimum guidelines and requirements for standards for accessibility and usability of federal and federally funded buildings and facilities by physically handicapped persons. Federal Register, January 16, 1981, 46, (11), 4270-4304.

Signage

In legal terms, the vast majority of visually handicapped persons possess a potentially useful amount of remaining vision. Of these individuals, the pathology affecting the visual system results in wide functional variation. For example, many individuals have an extremely restricted visual field, leaving only a small portion of useful vision in the center. Many others have a general decrement of visual acuity without serious loss of field. These are major variations, but it is important to realize that functionally related variations exist within each group.

With such wide variation in visual ability it is difficult to arrive at standards for signage which are useful to all. This is particularly so with respect to ideal size of graphic symbols and characters. However, some generalizations can be made which benefit a large majority of visually im impaired individuals and thereby ease the flow and immediacy of communication within rapid rail environments.

Visual acuity is generally reported with reference to the familiar Snellen fraction. Typically, measurements are taken at a standard distance of 20 feet which corresponds to the numerator of the fraction. Lines of characters decrease in size from top to bottom on the Snellen chart. Each line is referenced with a standard for normal vision. Thus, the line at the top can be read at 200 feet by a person with normal vision. The second line can normally be read at 100 feet. Each line progressively decreases in size until the 20 foot norm is reached. Thus, an individual who, while viewing the chart at a distance of 20 feet, can read as far down as the 20 foot line, has normal vision of 20/20. An individual who can read no further than the top 200 foot line would possess 20/200 vision. This is the borderline of legal blindness and may therefore serve as a useful standard for generalizing about the most optimally useful size for

for signs.

Snellen's 200 foot line (e.g., "E") is 3.5 inches high. Thus, individuals with best optical correction who cannot see this letter at a distance greater than 20 feet are considered legally blind. Since this is true only under optimal environmental conditions, it is appropriate to round off the 200 foot symbol to a size of 4 inches. By decreasing or increasing symbol size in relation to this standard size, statements can be made about the visibility of signage at various distances.

An individual who must approach the 200 foot standard (4 inches) to a distance of 5 feet can be said to have vision of 5/200 (20/800). Though grossly subjective, this is generally viewed as a cut-off point between visual (print) and tactile (braille) reading. The following table illustrates minimum symbol size and maximum viewing distances for such a severely visually impaired individual.

Estimated Visibility of Signage for an Individual with Vision No Greater Than 5/200 (20/800)

Minimum Symbol Size	Maximum Viewing Distance
16 inches	20 feet
12 inches	15 feet
8 inches	10 feet
6 inches	7.5 feet
4 inches	5 feet
2 inches	2.5 feet

Should standards for signage follow this table, the vast majority of visually impaired travellers should be able to read at these indicated distances. However, 16 inch lettering on signs which a traveller needs to

read from a distance of 15-20 feet is not always feasible. Factors such as message length affect viewing distance (i.e., visual angle). Logos such as those found at station entrances often equal if not exceed 16 inches in height, but this is an atypical illustration. A more conservative standard could be based on an individual with vision no greater than 10/200 (20/400).

The table which follows indicates the functions of signs at various distances for an individual with 10/200 vision.

Estimated Use and Visibility of Signage for an Individual with Vision No Greater Than 10/200 (20/400)

Minimum Size	Maximum Viewing Distance	Use of Information
8 inches	20 feet	station entrances
6 inches	15 feet	station name line name (from train and at station entrance)
4 inches	10 feet	train name (viewed from platform)
3 inches	7.5 feet	line transfer information inside station
2 inches	5 feet	route information on display maps

Though population estimates are extremely crude, this table would at least take into account the visual requirements of at least 70 percent of the low vision population.

Color

Color should be used to enhance orientation and direction finding, and to increase the number of discriminable symbols on maps for low vision

users. However, the effects of eye pathologies on color vision are extremely varied. This has resulted in a lack of good research establishing standards for color choice for low vision persons. In fact, there is some conflict in the results of research attempting to determine relative discriminability of different colors by the normal eye.

The requirements stated below are based primarily on general research in color perception and on knowledge of the effects of specific eye pathologies on color vision.

Explanations of three aspects of color specification will facilitate understanding of the recommendations for color selection to aid visually impaired persons.

Hue is the sensory correlate of wave length. The names of the primary colors, for example, designate hues.

Saturation or chroma refers to the strength or richness which a hue appears to possess. A stronger hue is said to be more saturated. Mixing white light with a color desaturates it, for example, turning red to pink.

Brightness or intensity is the relative amount of light reflected by a particular hue. Brightness value can be altered while hue and chroma remain constant. For example, a fluorescent red appears much brighter than the same red hue, of equal saturation, at lower intensity. It would, therefore, have greater contrast with black, for example, than a non-fluorescent red.

All persons having useful vision are able to perceive at least some differences in brightness, while many have difficulty discriminating different hues. Therefore, the primary guiding principle in color selection should be choice of color combinations with excellent contrast in brightness.

In one study (Chen, 1971), normal and color blind persons were found

equally accurate in color discrimination when brightness values of compared colors differed by 30%. Therefore, colors used in combination with each other should differ in brightness value from each other by a factor of at least 30%.

Yellow and orange appear to definitely be the most discriminable colors (hues) to the normal eye, the aging eye, the visually impaired eye, and the color-blind eye (which may not be otherwise impaired) (Gilbert, 1957; Chen, 1971; and Gaines & Little, 1975). Therefore, where colors are to be used, use of yellow or orange on a dark or black background should result in optimum visibility for the visually impaired as well as the non-visually impaired population. Other hues are less discriminable than these two, but conflicting research results make establishment of definite requirements in this area premature.

Graphic Aids

Graphic aids, as used in this discussion, will refer to maps or diagrams. These may be tactile (normally useful for only totally blind readers), visual (not useful for totally blind readers) or tactile-visual (theoretically useful for both totally blind and low vision persons).

Tactile Graphic Aids

The design of tactile graphic aids is "made difficult by the following paradox. In comparison to that of vision, the perceptual span for touch is extremely limited, making the task of reading maps far more difficult and prolonged. Consequently, tactual maps should be as small as possible. In comparison to that for vision, tactual acuity is much more coarse, requiring tactual figures to be much larger than visual figures in order to be discriminated. This requires tactual maps to be much larger than visual maps if the same information is to be presented" (Nolan & Morris, 1971, p. 75).

In designing tactile aids, requirements are needed for information content, scale, size, choice of symbols, information density, labeling and indexing. None of these areas has been thoroughly researched, however, Bentzen (1980) has reviewed the literature and summarized standards or guiding principles for the design of tactile graphic aids. The requirements stated below are taken from this chapter. All original sources are cited in the chapter.

Information Content

There are no empirically established requirements for information content, but it is well known that aids containing too much information are harder to read by touch than those containing less information. The amount of useable information on a tactile map is less than the total amount which can be haptically recognized. Therefore, only absolutely necessary information should be included.

Keys and indexes should be on pages separate from maps themselves.

Scale

Absolutely consistent scale is not essential to the usefulness of tactile maps. It is desirable, however, as blind travellers <u>do</u> use relative distances on maps to anticipate travel distances.

Two factors make absolute consistency of scale difficult to achieve on tactile graphic aids.

1) Adjacent symbols must be separated by 1/8 inch (3.2 mm) to be recognized as two discrete symbols.

2) The fixed dimensions of braille, where it is needed for labeling, may require alteration in scale of graphic information.

No requirements are established for absolute scale (e.g., 1 inch = 100 feet). This is usually a function of the complex interaction between information content, overall size of the aid, and choice of symbols.

Size

The overall size of a tactile graphic aid is probably best if it is not larger than the span of two hands placed together with the fingers outstretched, or 16 inches x 16 inches. Portable maps should, therefore, be no larger than 16 inches x 16 inches.

Larger maps, however, can be used by some blind persons for some purposes. Permanently mounted maps should probably not exceed 4 feet x 4 feet.

Symbols

For the past two decades, investigators have attempted to identify sets of discriminable lines, points and textures (areal symbols) for use on tactile graphics. At this time, the largest set of discriminable point symbols experimentally confirmed as being haptically discriminable is 13. The largest confirmed set of discriminable areal symbols is 8 (Bentzen, 1980). Symbols used on maps should be chosen from sets experimentally confirmed as discriminable, until future research identifies larger sets of discriminable symbols.

With a few specific exceptions, point sumbols should not be smaller than .20 inch in their largest dimension.

Line symbols which are single, narrow lines are traced faster and with fewer errors, and also yield better mental images than double or wide lines (Bentzen & Peck, 1979; Easton & Bentzen, 1980). Therefore, the primary line symbols chosen for transit maps should be those which are discriminable and which are single and narrow. They will, therefore, differ primarily in roughness (Bentzen & Peck, 1979; Easton & Bentzen, 1980).

Textures may be used on tactile maps to aid users in determining whether they are "in" or "out of" a particular area. However, overuse of textures may obscure more important information.

Textures should be used only when it is essential to identify an area or district on a map. When used, they should be at a height lower than that used for point or line symbols.

Differences in symbol height, both within and between symbol type, enhance symbol legibility. Materials and techniques for production of tactile graphic aids must, therefore, be able to produce symbols of varied elevation.

Information Density

Symbols which are placed too close together tend to be perceived as parts of each other rather than as discrete symbols. On tactile or tactile-visual maps, symbols should be separated by a minimum of 3.8 mm.

Labeling

Labels placed on tactile maps add to the problems on information content, scale, size and information density, yet labels will be essential on transit maps or city maps.

Braille labels should preferably be horizontal, should consist of a minimum of two braille cells, and they should be mnemonic (e.g., "ps" for Park Station) unless the number of labels precludes this system. Labels should be consistently placed in relation to symbols they identify.

To relieve the problem of information density, labels may satisfactorily be placed on an overlay.

A tactile grid may be provided on the margins of the map, on an overlay, or on an underlay (Lederman, 1980).

Visual Graphic Aids

The design of visual graphic aids (print maps) must consider the same requirements as the design of tactile graphic aids. Little definitive research has been done in this area, however, the conclusions of the litera-

ture search and experience of Bentzen (1980) are stated here in the form of suggested requirements.

Because all persons having low vision have either, or both, low visual acuity (requiring larger sized symbols and information) and reduced visual fields (requiring small scale and size), the same paradox exists in the design of visual graphic aids as in the design of tactile graphic aids. The following requirements consider the implications of both of these visual problems.

Information Content

Include only absolutely essential information. Keys and indexes should be on pages separate from all but the simplest maps.

Scale

Scale should be relatively consistent, so users can anticipate "travel distance" by interpreting "map distance".

Size

Portable maps should be no larger than 16 inches x 16 inches. Permanently mounted maps should not exceed 4 inches x 4 inches.

Symbols

A large majority of low vision persons will be able to discriminate symbols which are .20 inch in their largest dimension. The number of potentially visually discriminable symbols at this size is greater than the number of tactually discriminable symbols, however, sets of symbols discriminable to low vision persons have not been identified.

Letters and numerals are more versatile symbols on print graphic aids than on tactile graphic aids "because print which is less than 24 pt. type occupies less space than comparable braille letters and numerals. In addition, single print letters and numerals can be read without some of the confusion and ambiguity which may arise from the use of single cell braille

characters. The 26 letters of the alphabet, both capital and lower case, plus numerals one through nine, provide 61 symbols discriminable to most low vision readers, when reproduced in a space less than that occupied by one braille cell" (Bentzen, 1980, p. 321).

Print symbols should be chosen from shapes having some visual resemblance to what they represent.

Information Density

Minimum spacing of 1/8 inch (3.2 mm) between symbols is recommended.

Labeling

Labels should be at least 20 pt. type, bold face, and sans serif. Labels should be horizontal and mnemonic. They can be placed on a transparent overlay, if necessary, to reduce information content and density.

Choice of Materials and Colors

Materials should be matte finish. Choice of colors should adhere to the principles previously stated under the main heading, Color.

Tactile Visual-Graphic Aids

Since many of the requirements for tactile graphic aids and visual graphic aids are similar, and in no case are they contradictory, it may be preferred to make all maps for visually impaired persons both tactile and visual. This "dual" system has the following advantages:

1) Maps which are tactile as well as visual enable users who cannot see all the print information to acquire the balance of the information haptically.
2) If tactile maps also have print information, sighted persons are better able to assist blind persons in using them than if there is no print information.
3) One type of map will serve all visually impaired map users.

Textures

Research related to tactile walking surfaces has considered four factors:

1) The height of the surface in relation to surrounding surfaces
2) The type of texture
3) Material contrast between texture and floor surface
4) The dimensions of the texture

Height of Surface

Aiello & Steinfeld (1979) concluded that a texture should be raised from the floor at least 1/16 inch but no more than 1/8 inch to function as a tactile warning. Anything lower was not easily detected and anything higher became a tripping hazard. Maintenance of the surfaces raised higher was also more difficult.

Type of Texture

There have been several studies done to explore which types of textures would prove to be most effective. Templer (1980) conducted a study testing subjects who were totally blind, who had a high degree of partial vision, and who had a low degree of partial vision. Subjects familiarized themselves with several different textures which they would later be asked to detect. They then followed a path of these textured surfaces. Subjects stopped upon detecting changes in surfaces and then rated the ease of detectability. All of the trial textures were approached from a walk of light broom finish concrete. Of the different textures used the three most easily detected, in terms of reaction time and distance travelled, were thermoplastic strips, exposed aggregate, and pliant polymer. Exposed aggregate was the most easily detected, but it was found to adversely affect the mobility of the people travelling over it because of its rough surface. His recommendation was that this texture be used in a more refined

form so as not to affect mobility. He also recommended the use of Kushionkote, a tennis court covering material, becuase of its ease of detection as well as comfort, even though it was not among the top three.

The use of "tennis court covering" was further tested by Templer. In this study he laid down a straight, 100 foot long, 12 inch wide path of this texture on a sidewalk. He then had blind subjects try to walk a straight line down the sidewalk using this path as their guide. His findings were that the subjects were able, "without exception, to follow the textured....strip and use it to maintain a safe and direct course" (Templer, 1980).

Herms, Elias & Robins (cited in Templer, 1980b) described successful use of a tactile guide strip of epoxy cement with pea gravel embedded in it. This strip guides visually impaired pedestrians across confusing and complex intersections in San Diego.

General considerations in the choice of textures were that the surface should be stable, firm, and slip resistant (Templer, 1980a). Which type of texture to choose will be a function of cost of installation, maintenance and availability of materials.

Material Contrast

In general, the greater the contrast (in texture and color) between the warning or guide texture and its surrounding floor, the easier the texture will be detected by visually impaired travellers. Aiello & Steinfeld (1979) recognized that contrast between floor surface and textured signal could be created not only by a difference in texture but by a difference in pliability. The textured area could be considerably harder or softer than the surrounding floor surface.

Templer (1980b) followed up this suggestion in the materials he used in his texture studies. The pliant polymer and Kushioncote both

differed in pliability from surrounding surfaces, and were found easy to detect.

Dimensions of Textured Areas

Aiello & Steinfeld (1979) felt that the critical dimension was the distance between a warning signal (texture) and a hazard. Based on research results regarding stopping distance, they recommended that the signal extend 18 to 36 inches from the hazard. Templer (1980a) more specifically recommends the dimensions of a tactile warning strip as "at least 24 inches (610 mm) wide extending at least 36 inches (915 mm) from the hazard running the width of the hazard".

Although there is no conclusive research on the width of textured paths, the following have been successfully used. Herms, Elias, & Robins (cited in Templer, 1980b) used a guide strip of 2 inches (5.08 cm) wide and 1/4 inch (6.35 cm) thick running the length of the walkway. Templer (1980b) used a 12 inch (30.48 cm) wide strip running the length of the test area, which was 100 feet.

Audio Cueing

Blind travellers use sounds to help them locate specific objects which may emit sounds (as in using the sound of the opening vehicle door to locate that door), and to navigate in a straight line through open spaces (as in using the sound of persons passing through turnstiles to cross an open area between stairs and the fare collection system). Provision of various audio cues at key positions in transit stations and vehicles will facilitate spatial orientation and enhance the safety of visually impaired transit users.

ANSI standards (1980) regarding audible alarms state that "if provided, audible emergency alarms shall produce a sound that exceeds the prevailing

sound level in the room or space by at least 15 db or exceeds any maximum sound level with a duration of 30 seconds by 5 db, whichever is louder. Sound levels for alarm signals shall not exceed 120 db" (ANSI, 1980, p. 45). Standards stated by the ATBCB (Federal Register, January 16, 1981) are similar.

In determining the optimal character of a sound signal, many issues should be considered.

In an experiment of directional hearing ability of normal-hearing blind persons and persons with normal hearing and normal sight, no difference in localization ability between the two populations could be demonstrated. For the blind persons, orientation may be facilitated by fixed, appropriate sound sources. Normal-hearing persons are expected to benefit from this arrangement, and it may be of help also for persons with impaired hearing (Tonning, 1975).

<u>Signal Intensity</u>

A group of tests of primary auditory abilities was presented to three groups of listeners: normal sighted persons, expert blind travellers, and homebound blind subjects. Test results indicate that the expert blind travellers exhibit an increased sensitivity to differences in intensity as compared with either the homebound or normally sighted subjects. Their sensitivity to frequency changes is not different (Curtis & Winer, 1969). This study reached no conclusions regarding the optimal difference between the signal intensity of an audio cue and ambient noise. However, this is probably considerably lower than the minimum difference in intensity required by ANSI for audible alarm systems.

Tonning (1965) and Hulscher (1976) suggest varying the signal sound intensity according to the varying intensity of ambient sounds. This will minimize the "noise pollution" of the additional audio cues, while

maintaining intensity sufficient for visually impaired persons to localize sound sources accurately.

Signal Frequency

Noise and complex sounds are more easily localized than pure tones (Jonkees and Groen, 1946; Norlund, 1962, 1964; Tonning, 1965). When pure tones are used, excellent localization can be achieved if the tones are between 250-1000 Hz. and 3000-6000 Hz. (Yost & Nielsen, 1977). Hulscher (1976) contends that optimal frequency range for a sound signal is 300-1000 Hz.

Signal Duration

Tonning (1965) states that, based on the work of Christian and Röser (1957), acoustical stimuli are better localized when presented as short pulses, and concludes that the ideal sound signal should be a pulsatory noise/complex sound. Hulscher concurs, stating that a transient sound, of a duration shorter than the integration time of the ear, is more accurately localized by persons with either monaural or binaural hearing.

Summary

Non of the research cited has considered the use of sound signals in enclosed environments such as rail rapid transit stations, or the specific problems of choosing frequencies which are not likely to be duplicated by ambient sound in rapid transit environments. Nonetheless, it is anticipated that pulses of sound, of mixed frequencies, and at higher intensity than ambient noise, will be effective aids to spatial orientation.

Sound Signals in Current Use and Evaluation

Hulscher (1976) cites many examples of sound signal systems worldwide which are currently being evaluated. One of the most popular is the Swedish "ticker", used at light controlled intersections, which also possesses a tactile feature. This device emits a continuous low clicking sound at a

rate of 75 Hz. which increases to 800 Hz. during the pedestrian crossing interval. The low-rate signal assists in call-box localization.

A West German sound signal system produces sound frequencies between 450 Hz. and 800 Hz., while a system in Denmark uses a frequency of 880 Hz.

Electronic Cueing Devices

Several electronic travel aids have been developed and are in limited use by visually impaired travellers. These devices, and the kinds of feedback which they give users, will be described below. The feedback systems used were not chosen on the basis of exhaustive research into auditory and vibro-tactile perception, but were educated guesses of experienced persons. They work for most users; therefore, they would probably be appropriate feedback systems to use in electronic cueing devices developed especially for blind users of rail rapid transit.

There are two types of electronic travel aids which may be described as obstacle detectors or environmental sensors. Both types are designed to be used in addition to another travel aid such as a long cane or dog guide.

Obstacle detectors in use in the United States are the Pathsounder, the Laser Cane, and the Mowat Sensor. All give signals to users when there is an obstacle in the path of the user. They give no information regarding the nature of the obstacle. An obstacle detector "detects and locates objects, provides information that allows the user to determine (within acceptable tolerances) range, direction, dimension and height of objects. It makes noncontact trailing and tracking possible, enabling the traveller to receive directional indications from physical structures that have strategic location in the environment" (Farmer, 1980, pp. 372-373).

The Pathsounder is a small, battery-operated sonar device, mounted on the chest. It emits bursts of ultrasonic waves into space 15 pulses-per-

second with a maximum diameter sonic cone of approximately 20-24 inches (50-61 cm) at a distance of 6 feet (182 cm) from the traveller's chest. The E Model Pathsounder has two output signals, vibratory (tactile) and auditory. When there is an object within 6 feet (182 cm), the auditory output is an intermittent buzzing sound, which changes to a high-pitched beeping sound if an object appears within a 32 inch (81 cm) range (Farmer, 1980). The vibratory system was incorporated to serve the hearing-disabled blind person, to replace an auditory signal in a noisy location where masking of sounds might take place, and as an inconspicuous private signal (Russell, 1974).

The C-5 laser cane is an obstacle detector which emits pulses of infrared light which, if reflected from an object in the travel path, are detected by photodiodes located behind the receiving lens. The signal emitted by a downward-looking channel emits short 200 Hz. rasping tones to notify the user of any dropoff greater than 6 inches (15 cm), which appears 3 feet (0.9 m.) in front of the cane tip (or 6 feet (1.82 m) in front of the user). A straight-ahead beam can activate a pin-like stimulator that vibrates against the index finger. In addition, an auditory signal consisting of a 1600 Hz. tone may be switched on or off. An upward-looking beam will detect obstacles at head height appearing approximately 30 inches (76 cm) from cane tip. Upper obstacle detection is signaled by high-pitched (2600 Hz.) tones (Bionic Instruments, Inc., 1976).

The Mowat Sonar Sensor transmits a beam of high-frequency ultrasound which has a vibratory output. When an object is detected, the Sensor vibrates at a rate inversely related to the distance from the object. At 13 feet (4 m) from a target, the aid vibrates at a rate of 10 pulses-per-second and increases to a vibratory rate of 40 pulses-per-second when the traveller advances to within 3.3 feet (1m) of the target (Farmer, 1980).

The Sonicguide is considered an environmental sensor, and differs from the obstacle detectors in that it also gives information about the surface characteristics and density of objects in the environment. (The obstacle detectors, for example, will emit signals to their users when approaching obstacles such as columns or persons which are in one's line of travel. The sonicguide user will be able to discern, by differences in the quality of the auditory feedback from his aid, which of these objects is most likely to be able to tell him whether the approaching train goes all the way to Quincy.) The Sonicguide emits pulses of inaudible high frequency sound ahead of the user from small transducers mounted on a pair of spectacles. The sound reflects back from objects within the ultrasonic field, is converted to an audible signal and is fed to binaural receivers for interpretation by the user. The distance of an object (at a maximum range of 12 to 20 feet or 3.6 to 6.0 m) is conveyed by the perceived pitch of the sounds produced. The pitch continuously goes lower as the distance between the traveller and an object decreases (Farmer, 1980).

Flashing Lights

Flashing lights are recommended for visual alarm devices. These might, in some situations, be used to give directional information to low vision persons. Requirements for such signals by low vision persons are not known to differ from those for the general population. However, a significant porition of low vision persons have epilepsy, and seizures may be triggered by a range of flicker frequencies. Epileptics are sensitive to frequencies in the alpha-rhythm range (8-14 Hz.), and these frequencies should be avoided in the signal device (Hulscher, 1976). ANSI standards require that the flashing frequency of visual alarm devices shall be less than 5 times per second (ANSI, 1980). In apparent contradiction, Dr. J.K. P ry, M.D., Chief of the Epilepsy Branch of Neurological Disorders Program,

National Institute of Health, confirms that "the peak range of photosensitivity among patients suffering from epilepsy is between 4 and 16 flashes per second". He recommends that flashes or stimuli be paired and have 100 milliseconds between flashes, or in other words, they would be paired flashes at 60 times per minute (Electroencephalography and Clinical Neurophysiology, 39: 479489, 1975). It is the opinion of Dr. Penry and of Wheelock Signals that a flash rate of 1 flash per second is high enough to command attention but below the limit where photosensitive epileptic seizure will result. Gallaudet College (for deaf persons), for example, uses high intensity lights which flash once per second for four minutes (Federal Register, August, 1980, p. 55062).

Summary

Braille

1) Standard, grade 2 braille should be used for the production of schedules, tables, and descriptive information.
2) Short labels should be produced in jumbo braille, where space permits.

Raised Print

1) Short labels should be produced in raised type, with <u>sans serif</u> capital letters, 5/8 inch (16 mm) - 2 inch (50 mm) high.
2) Incised letters are not to be considered a means for communicating with blind persons.

Large Type for Near and Distant Reading

1) It has been recommended elsewhere that schedules, tables, and descriptive information should be published in 18 pt., bold, <u>sans serif</u> type.
2) Signs should follow ANSI standards with regard to proportions, and

letters should be from 2 inches to 16 inches high, depending on the distance from which they are to be read.

Color

1) Brightness values of colors appearing together should differ from each other by at least 30% for maximum discriminability.
2) Yellow and orange (on black or dark backgrounds) are the most visible and discriminable colors for normally sighted and low vision persons.

Graphic Displays (Tactile, Large Type, or Tactile-Visual Maps)

1) Maps should contain only essential information.
2) Scale should be reasonably consistent.
3) Portable maps should be no larger than 16 inches x 16 inches.
4) Permanently mounted maps should not exceed 4 feet x 4 feet.
5) Symbols which have been experimentally determined to be discriminable from each other should be used on all maps.
6) Line, point and areal symbols should differ in height, for maximum discriminability.
7) Symbols should be separated by a minimum of 3.8 mm.
8) Visual graphic displays (maps) can utilize color to achieve a greater number of discriminable symbols.
9) Tactile-visual graphic aids are recommended to serve the largest number of visually impaired persons with one aid design.

Textural Coding

1) Textured warning strips are <u>probably</u> appropriate indicators of caution at edges of drops.
2) Textured guide strips are <u>probably</u> useful as direction indicators.
3) No specifications for such textures have been empirically validated by visually impaired pedestrians.

Audio Cueing

1) The easiest sounds to localize are of mixed frequencies and they are intermittent pulses.

2) Sound intensity should be above ambient noise levels.

Electronic Cueing

1) Currently used electronic travel aids give both auditory and vibro-tactile feedback.

2) Flashing lights should adhere to ANSI standards in terms of frequency of flashes.

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A GLOSSARY OF DEFINITIONS RELATED TO VISUAL IMPAIRMENT

Introduction

This report contains a 107-item glossary of definitions related to visual impairment, which can be used by transit personnel in communications and publications referring to visually impaired individuals. The items have been selected on the basis of relevance to issues of interest for transit personnel. The definitions have been selected either from existing works on the basis of accuracy, or written specifically for this glossary. Those definitions which have been taken from other works are followed by a number which corresponds to a reference listed below.

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Glossary

ACCOMMODATION - The adjustment of the eye for seeing at different distances, accomplished by changing the shape of the Crystalline lens through action of the ciliary muscle, thus focusing a clear image on the retina. (4)

ALBINISM - An hereditary loss of pigment in the iris, skin, and hair; usually associated with lowered visual acuity, nystagmus and photophobia and often accompanied by refractive errors. (4)

ALIGNING (ALIGNMENT) - The act of establishing a line of travel parallel to a direction indicator such as a wall or moving sound such as a subway vehicle in order to facilitate maintenance of straight line of travel.

AMBLYOPIA - Dimness of vision without any apparent disease of the eye. (4)

APHAKIA - Absence of the lens of the eye. (4)

ARC - The path of the cane tip as the cane is moved in the touch cane technique. (1)

ASTIGMATISM - Refractive error which prevents the light rays from coming to a single focus on the retina because of different degrees of refraction in the various meridians of the eye. (4)

AUDITION - The process of relating to or experiencing through hearing. (3)

AUDITORY - Related to or experienced through the sense of hearing. (3)

BINAURAL - Hearing with, of, relating to, or used with both ears. (5)

BINOCULAR VISION - The ability to use the two eyes simultaneously to focus on the same object and to fuse the two images into a single image which gives a correct interpretation of the object's solidity and position in space. (2)

BLINDNESS - In the United States, the legal definition of blindness is: central visual acuity of 20/200 or less in the better eye after correction; or visual acuity of more than 20/200 if there is a field defect in which the widest diameter of the visual field subtends an angle distance no greater than 20 degrees. (4) A person who at a distance of 20 feet can clearly distinguish only the largest (top) E from the Snellen eye chart would be given the visual acuity of 20/200. A "normally" sighted person would be able to distinguish only the largest E at a distance of 200 feet. A person with a visual field restricted to 20 degrees could only see the area of a 10 inch dinner plate at a distance of 29 inches without shifting his gaze.

BODY IMAGE (AWARENESS) - An individual's conceptualization of the size, shape, function, and movement of his body parts and of their relationship to each other.

BUMPER PROTECTION - Frontal protection offered by techniques which keep an arm(s) or cane in front of the body, e.g., protective techniques and diagonal cane techniques. (1)

CANE - see LONG CANE.

CATARACT - A condition in which the Crystalline lens of the eye, or its capsule, or both become opaque. (4)

CENTRAL VISUAL ACUITY - Ability of the eye to perceive the shape of objects in the direct line of vision. (4)

CLEAR (CLEARING) - The process of confirming the safety of an area either with a sweep of the cane tip on the ground or with a sweep of the hand on the surface. (3)

CLUE - Any sensory information (sound, odor, temperature, tactile, or visual stimulus) which assists the person in identifying objects or in determining position or line of direction. A clue is most useful when it is position or line of direction. A clue is most useful when it is permanent, constant, recognizable and accessible.

COLOR DEFICIENCY - Diminished ability to perceive differences in color - usually for red or green, rarely for blue or yellow. (4)

CONGENITAL - Present at birth. (4)

CONVERGENCE - The process of directing the visual axes of the two eyes to a near point, with the result that the pupils of the two eyes are closer together. The eyes are turned inward. (4)

CUE - Any sound, odor, thermal, tactile or visual stimulus affecting the senses which will elicit an immediate or automatic response. (3)

CUTANEOUS SENSORY INFORMATION - A composite of sensory information arising from receptors in the skin, especially tactual (touch) and thermal (temperature) sensory information. (5)

DARK ADAPTATION - The ability of the retina and pupil to adjust to a dim light. (4)

DEPTH PERCEPTION - One's determination of the distance of an object from himself using visual clues.

DIAGONAL CANE TECHNIQUE - Use of a cane to provide frontal bumper protection. The cane is held diagonally across the lower half of the body. (1) It does not protect the user from low obstacles on the side opposite the cane tip, nor from obstacles above the waist.

DIPLOPIA - The seeing of one object as two. (4)

DIRECTION INDICATOR - Any environmental sensory information which is utilized to establish a line of travel and/or is utilized as a reference point. (5)

DOG GUIDE - Specially trained dogs useable by a small percentage of the blind population as an aid in avoiding hazards and locating landmarks.

DYSLEXIA - Inability to read which is apparently due to a neurological problem.

ECHOLOCATION - The technique of locating objects by emitting sounds and interpreting the echos (e.g., a blind person may walk parallel to a wall by interpreting the echos of his footsteps).

ELECTRONIC TRAVEL AID - Electronic devices which assist the blind traveller in locating or identifying landmarks and finding a clear path of travel. All current varieties are usually in conjunction with a long cane.

EYE DOMINANCE - The tendency of one eye to assume the major function of seeing, being assisted by the less dominant eye. (4)

FACIAL VISION - The term applied to the once widely held belief that objects could be perceived through skin sensations. (See OBJECT PERCEPTION - 5.)

FAMILIARIZATION (FAMILIARIZE) - The process of learning the spatial characteristics of an environment and the locations of objects within that environment through a series of systematic sensory inputs and experiences.

FIELD OF VISION - The entire area which can be seen without shifting the gaze. (4)

FLOATERS - Small particles consisting of cells or fibrin which move in the vitreous. (4)

FOCUS - Point to which rays are converged after passing through a lens; focal distance is the distance rays travel after refraction before focus is reached. (4)

FUSION - The power of coordinating the images received by the two eyes into a single mental image. (4)

GUIDELINE - The border between two surfaces such as the junction of a paved and a non-paved area. A guidelines can be detected and followed with a long cane.

HANDTRAIL - To follow a parallel surface by constant contact with either hand. (1)

HAPTIC PERCEPTION - Perception yielding spatial judgements of size, shape, location, etc. arising from a composite of tactual and proprioceptive sensory information. (5)

HEMIANOPSIA - Blindness of one-half the field of vision of one or both eyes. (4)

HYPEROPIA - A refractive error in which, because the eyeball is short or the refractive power of the lens weak, the point of focus for rays of light from distant objects (parallel light rays) is behind the retina; thus, accommodation to increase the refractive power of the lens is necessary for distant as well as near vision. (4)

JAEGER TEST - A test for near vision; lines of reading matter printed in a series of various sizes of type. (4)

LANDMARK OR PRIMARY CLUE - A familiar, permanent, constant, recognizable, accessible clue which indicates spatial relationships; used as an orientation check along a route.

LIGHT PERCEPTION - The visual ability to detect the presence or absence of light.

LIGHT PROJECTION - The visual ability to detect light and determine the direction of the light source.

LINE OF TRAVEL - The course along which a person is moving. (3)

LOCALIZE - The process of determining the relationship in space between oneself and an object(s) using the available sensory information.

LONG CANE - A lightweight cane of prescribed length which is an obstacle detector and environmental sensor for the blind pedestrian. They are typically white, with a six inch red stripe above the lower tip, and are longer than an orthopedic cane.

LOW VISION - When impairment in the visual system interferes with normal daily functioning.

LOW VISION AIDS - Optical devices of various types useful to persons with vision impairment. (2)

LOWER ARM PROTECTION TECHNIQUE - A technique which uses the forearm to protect the traveller's midline body at groin or upper thigh level while the person is walking.

MASKING SOUND - A sound which interferes with the reception of or blocks out a desired sound. (5)

MOBILITY - The process of moving from one's present position to a desired locale safely and effectively with and/or without the use of a travel aid.

MOBILITY INSTRUCTOR - Any professionally trained orientation and mobility teacher, specialist or peripatologist. (1)

MYOPIA (NEARSIGHTEDNESS) - A refractive error in which, because the eyeball is too long in relation to its focusing power, the point of focus for rays of light from distant objects (parallel light rays) is in front of the retina. Thus, to obtain distinct vision, the object must be brought nearer to take advantage of divergent light rays (those from objects less than 20 feet away).

NEGOTIATE - To travel around an object in one's line of direction while remaining oriented to one's environment. (1)

NYSTAGMUS - An involuntary, rapid movement of the eyeball, which may be lateral, vertical, rotary, or mixed. (4)

OBJECT PERCEPTION - The process of determining the presence of an object in one's path through use of reflected auditory information. This process has historically been referred to as "Facial Vision" and incorrectly attributed to the development of a sixth sense in the skin of blind persons.

OCULIST (OPHTHALMOLOGIST) - A physician who is licensed to practice medicine and surgery and who specializes in diagnosis and treatment of defects and diseases of the eye. (4)

OCULUS DEXTER (O.D.) - Term denoting the right eye.

OCULUS SINISTER (O.S.) - Term denoting the left eye.

OCULUS UTERQUE (O.U.) - Term denoting both eyes.

OPHTHALMOSCOPE - An instrument used in examining the interior of the eye. (4)

OPTIC ATROPHY - Degeneration of the nerve tissue which carries messages from the retina to the brain. (4)

OPTICIAN - One who grinds lenses, fits them into frames, and adjusts the frames to the wearer. (4)

OPTOMETRIST - A licensed, nonmedical practitioner who measures refractive errors and eye muscle disturbance. In treatment the optometrist uses glasses, prisms, and exercises only. The letters O.D. follow the name. (4)

ORIENTATION - The process of utilizing the remaining senses in establishing one's position and relationship to all other significant objects in one's environment. (3)

ORTHOPTIC TRAINING - A series of scientifically planned exercises for developing or restoring the normal teamwork of the eyes. (4)

PARALLELING - The utilization of auditory or visual sensory information to establish and maintain a line of travel parallel to the source of sensory information. (5)

PARTIALLY SIGHTED - A person whose best corrected visual acuity in the better eye does not exceed 20/70 but is better than 20/200.

PERIPATOLOGY - The art and science of aiding a blind or visually handicapped invididual to move about her/his environment safely, effectively and with confidence. (5)

PERIPHERAL VISION - The ability to perceive the presence, motion, or color of objects outside of the direct line of vision. (5)

PHOTOPHOBIA - Abnormal sensitivity to and discomfort from light. (5)

PRESBYOPIA - A gradual lessening of the power of accommodation due to physiological change which becomes noticeable after the age of forty. (5)

PROTECTIVE TECHNIQUES - The use of the body or an aid to protect the individual from encountering potentially dangerous obstacles (including protruding objects, fire hydrants, stairs, potholes, etc.).

PSEUDOISOCHROMATIC CHARTS - Charts with colored dots of various hues and shades indicating numbers, letters, or patterns, used for testing color discrimination. (4)

REACTION DISTANCE - The actual space between the visually handicapped individual and an object detected through use of a protective system (body or cane).

REACTION TIME - The time equivalent of the reaction distance. (1)

REFRACTION - 1) The deviation in the course of the rays of light in passing from one transparent medium into another of a different density. 2) The determination of refractive errors of the eye and correction by glasses. (4)

REFRACTIVE ERROR - A defect in the eye that prevents light rays from being brought to a single focus exactly on the retina. (4)

RETINITIS PIGMENTOSA - (Primary Pigmentary Degeneration) Hereditary degeneration and atrophy of the retina. There is usually misplaced pigment. (4)

SCANNING - Systematic search of the sensory array in one's environment for the desired sensory information.

SCOTOMA - A blind or partially blind area in the visual field. (4)

SIGHTED GUIDE TECHNIQUE - The use of a sighted person as an aid for travelling. The visually handicapped person grasps his guide's arm just above the elbow with a firm yet relaxed grip, and follows about a half step behind the guide. This allows sufficient time to react to the guide's starting, stopping, turning or stepping up or down.

SOLICITING AID - The act of requesting assistance from a sighted person in order to reach a destination or overcome a temporary situation such as auditory confusion, an uncontrolled intersection or unfamiliar territory.

SOUND MASKING - See MASKING SOUND.

SOUND SHADOW - A change in sound created when there is an object between a sound source and the perceiver. (5)

SPATIAL ORIENTATION - The act of establishing environmental interrelationships (i.e., between self, others, objects) within a context of a reference system. This implies a functional body schema, awareness of objects, effective perceptual-motor behavior and appropriate concept functioning (e.g., location, direction distance, shape, etc.). (5)

SNELLEN CHART - A display used for testing central visual acuity. It consists of lines of letters, numbers, or symbols in graded sizes drawn to Snellen measurements. Each size is labeled with the distance at which it can be read by the normal eye. Most often used for testing vision at a distance of 20 feet. (4)

SQUARING OFF - The act of establishing a line of travel perpendicular to a direction indicator.

STEREOSCOPIC VISION - The ability to perceive relative position of objects in space without such cues as shadow, size, and overlapping. (4)

STRABISMUS (CROSS EYE) - The failure of the two eyes simultaneously to direct their gaze at the same object because of muscle imbalance. (4)

SYMPATHETIC OPH ... to an infection in
the other ...

TACTILE - Chara ... ble by active or
passive to ...

TACTUAL SENSORY ... ng from receptors
in the ski ... (see Cutaneous
Sensory In ...

TANGENT SCREEN ... d by a framework on
which the ... been lightly
outlined. ... he central field of
vision. (...

TIME/DISTANCE ... tive sensory infor-
mation to ... t travelling. (5)

TONOMETER - An ... the eye, called
intra-oc ...

TRACING - The ... on to follow the
outline ...

TRACKING - The ... follow the path
of a mov ...

TRAILING - The ... hand or by cane in
order to ... a specific objective
or estab ...

TUNNEL VISION - Contraction of the visual field giving the affected individual
the impression of looking through a tunnel. (4)

UPPER HAND AND FOREARM PROTECTIVE TECHNIQUE - The positioning of the hand
and forearm in a horizontal position in front of the body at shoulder
height, with the palm forward, fingers extended, together and relaxed.

REFRACTION - 1) The deviation in the course of the rays of light in passing from one transparent medium into another of a different density. 2) The determination of refractive errors of the eye and correction by glasses. (4)

REFRACTIVE ERROR - A defect in the eye that prevents light rays from being brought to a single focus exactly on the retina. (4)

RETINITIS PIGMENTOSA - (Primary Pigmentary Degeneration) Hereditary degeneration and atrophy of the retina. There is usually misplaced pigment. (4)

SCANNING - Systematic search of the sensory array in one's environment for the desired sensory information.

SCOTOMA - A blind or partially blind area in the visual field. (4)

SIGHTED GUIDE TECHNIQUE - The use of a sighted person as an aid for travelling. The visually handicapped person grasps his guide's arm just above the elbow with a firm yet relaxed grip, and follows about a half step behind the guide. This allows sufficient time to react to the guide's starting, stopping, turning or stepping up or down.

SOLICITING AID - The act of requesting assistance from a sighted person in order to reach a destination or overcome a temporary situation such as auditory confusion, an uncontrolled intersection or unfamiliar territory.

SOUND MASKING - See MASKING SOUND.

SOUND SHADOW - A change in sound created when there is an object between a sound source and the perceiver. (5)

SPATIAL ORIENTATION - The act of establishing environmental interrelationships (i.e., between self, others, objects) within a context of a reference system. This implies a functional body schema, awareness of objects, effective perceptual-motor behavior and appropriate concept functioning (e.g., location, direction distance, shape, etc.). (5)

SNELLEN CHART - A display used for testing central visual acuity. It consists of lines of letters, numbers, or symbols in graded sizes drawn to Snellen measurements. Each size is labeled with the distance at which it can be read by the normal eye. Most often used for testing vision at a distance of 20 feet. (4)

SQUARING OFF - The act of establishing a line of travel perpendicular to a direction indicator.

STEREOSCOPIC VISION - The ability to perceive relative position of objects in space without such cues as shadow, size, and overlapping. (4)

STRABISMUS (CROSS EYE) - The failure of the two eyes simultaneously to direct their gaze at the same object because of muscle imbalance. (4)

SYMPATHETIC OPHTHALMIA - An inflammation of one eye due to an infection in the other eye. (4)

TACTILE - Characteristics of objects which are perceivable by active or passive touch. (5)

TACTUAL SENSORY INFORMATION - Sensory information arising from receptors in the skin stimulated by active or passive touch (see Cutaneous Sensory Information).

TANGENT SCREEN - A large black or gray curtain supported by a framework on which the normal central field and blind spot have been lightly outlined. This instrument is used for measuring the central field of vision. (4)

TIME/DISTANCE JUDGEMENT - The utilization of proprioceptive sensory information to estimate distance travelled or time spent travelling. (5)

TONOMETER - An instrument for measuring pressure inside the eye, called intra-ocular pressure. (4)

TRACING - The use of visual or haptic sensory information to follow the outline of an object.

TRACKING - The use of visual or auditory information to follow the path of a moving object or objects.

TRAILING - The act of following a surface visually, by hand or by cane in order to determine one's position in space, locate a specific objective or establish a parallel line of travel.

TUNNEL VISION - Contraction of the visual field giving the affected individual the impression of looking through a tunnel. (4)

UPPER HAND AND FOREARM PROTECTIVE TECHNIQUE - The positioning of the hand and forearm in a horizontal position in front of the body at shoulder height, with the palm forward, fingers extended, together and relaxed.